Design and additive manufacturing of new high-performance structural catalysts for environmentally friendly hydrogen sulfide utilization

- popular science abstract

Hard to bear smell of rotten eggs is in fact due to hydrogen sulfide that is emitted from protein-containing wastes such as sewage but not only from that. The odour informs us partly of the toxicity which for hydrogen sulphide is comparable with that of carbon monoxide or cyanides. When the odor of this gas stops, it does not mean that it is no longer present in the atmosphere as our receptors could be overcharged not responding properly. The odour threshold of hydrosulfide is indeed very low as we can smell yet 0.47 parts per billion or even less. The 10 parts per million (ppm) is the permissible exposure limit for 8 hours. Above it, hydrosulfide brings about eye irritation and at around 100 ppm causes olfactory nerve paralysis and further pulmonary edema. For this reason, the emissions of even low amount of it to the atmosphere pose a serious environmental problem to which this project responses.

It is also a natural response to the lack of the solutions for hydrogen sulfide abatement that would be able to deal with its low but still poisonous amounts emitted to large streams of air. This is the case of copper mines in Poland, where the ventilation airflow is 300 000 m^3 per hour and contains 1-100 ppm H_2S. Although the project is pure research at a fundamental level, it is hard to resist a temptation that the best solution for copper mines would be to utilize the odour directly at the mine's workings to improve the labour conditions and to cease the emission which is burdensome for the people living in the vicinity of copper mines.

Thus, our goal in this project is to **develop efficient method of hydrogen sulfide utilisation** by catalytic combustion by using a concept of **ceramic structured reactors obtained by additive 3D manufacturing** popularly called 3D printing.

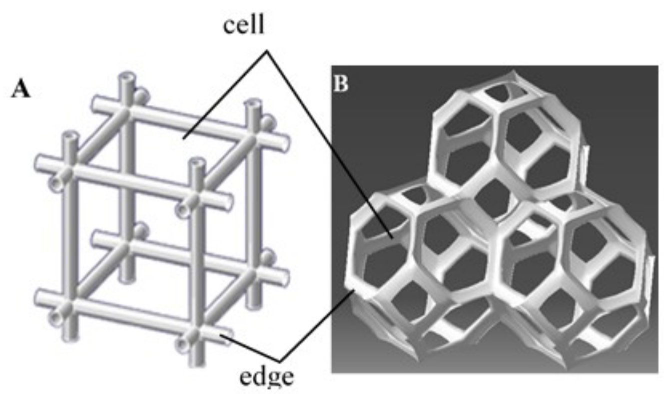

Fig. 1. A) 3D cubic cell structure, B) tetrakaidecahedron *(TTKD) structure*

The most popular structured reactors made of channels are the ceramic monoliths which are commonly used in the chemical and automotive industry for pollution control. An idea of structured chemical reactors can be expanded to well defined 3D structure, as shown in Figure 1. Our purpose is to be able to design them at the same level of sophistication at which microprocessors are designed and combined into complex electronic systems used for computational purposes. It seems that, in comparison with electronics, chemical engineering is lagging substantially behind. In this way this project is a logical reaction to the urgent need to develop a new strategy for reactor design, in which packed beds; still the most widespread reactor types, are replaced by structures designed down to the molecular level.

This can be achieved by engaging the techniques of additive manufacturing. While 3D printing is fairly well-developed for plastics with better or worse quality depending on the purpose, it still needs a lot of surveys as far as ceramics is regarded. Ceramics is the most advantageous material for the reactor structured internal that could look like the forms presented in Figure 1. An ultimate goal, however, would be to imprint catalyst material, or more precisely, the active centres on top of such structures with use of additive manufacturing methods. This can be achieved provided that their structure is known at a molecular level at which the reactants molecules meet on catalyst surface and react. This is possible provided that advanced methods of in situ spectroscopic investigation of the surface will be engaged which is the main chemical analytical tool in our project.